Development and Flight Qualification of a Low Cost Distributed Irradiance Monitoring System (DIMS)

Completed Technology Project (2017 - 2019)

Project Introduction

Solar radiation is the critical source of energy for the majority of biological processes on Earth. The Sun drives the Earth's energy balance and is critical to our understanding of the atmosphere and climate. Sophisticated models with important societal impacts such as atmospheric conditions and climate change demand an accurate and precise energy input. Current era measurements of total solar irradiance began in 1979 with NASA's Earth Radiation Budget (ERB) satellite and continue today through the Solar Radiation and Climate Experiment (SORCE) mission. However this instrument has had coverage gaps due to hardware problems, and could reach end of life before the planned successor mission, NOAA's Total Solar Irradiance Sensor (TSIS). The Total Solar Irradiance Calibration Transfer Experiment (TCTE) was launched in 2013 in anticipation of continuing coverage post-SORCE. However, this instrument is intended for only a 1.5 year lifetime. Future coverage gaps are therefore an increasingly likely problem in a time when climate modelling has become increasingly important. Calibration between missions is a necessary effort to maintain data integrity and is rendered impossible when one mission ends before the launch of its successor. Lastly the SORCE instrumentation requires constant re-calibration to account for instrument degradation, adding additional cost and uncertainty to the data. We propose a new model for solar irradiance monitoring. Instead of large scale, long lead, high cost, and inherently risky instrumentation, we propose to investigate a distributed network of low cost, low risk, replaceable irradiance monitoring cubesats. This network would provide complementary data to aid the calibration of existing instruments as well as a means of providing continuity between missions at low cost. We propose to engage with the University of Colorado in supporting a Senior Design Team within the Department of Aerospace Engineering to develop a 1U Cubesat prototype instrument. This prototype will incorporate a pair of UV-VIS spectrometers (200-1100nm detector sensitivity) and a space qualified controller. The instrument would be tested using a ride-along opportunity on an existing NASA supported high altitude balloon (HIWIND) scheduled for flight in 2017. By using this platform, we can leverage the existing power infrastructure and prove the scientific instrument with minimal cost and risk. This flight qualification on a balloon, while not a perfect space qualification, will significantly reduce the risk for future space flight. By using the cubesat form factor this instrument can then be augmented in the future with an additional 1-2 Units for power, attitude control, telemetry needed for space flight. The long term plan (for future proposals) is to partner with commercial (e.g. communication) satellite providers to launch these as piggyback "modules", with a business model of providing spectral irradiance data to commercial and government interests. The accuracy and precision of irradiance measurements would then be obtained, not by expensive instrumentation, but by the statistical noise reduction gained from a network of multiple instruments. This proposal fits within the NASA Science Plan which prioritizes new sustained solar irradiance measurements as a "National Priority" particularly in the 2020 timeframe.

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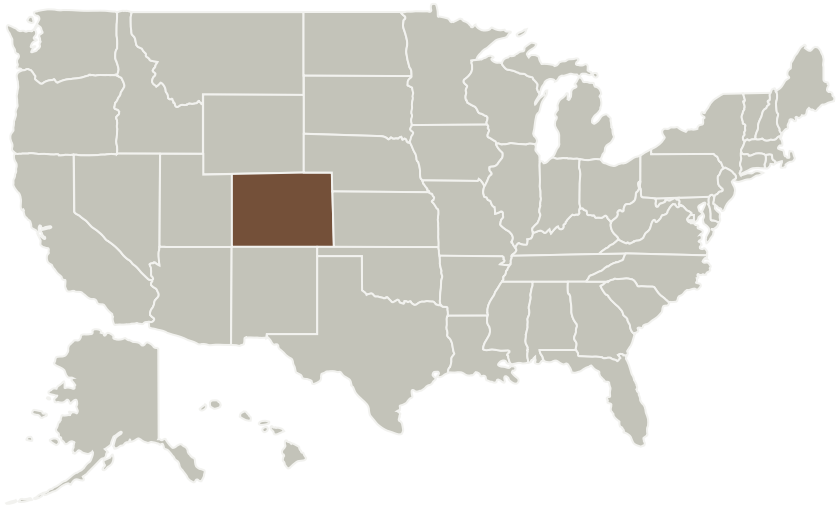
Additionally, the Heliophysics Decadal Review sets priority to "Establish mechanisms for maintenance and continuity of essential long-term data sets" and explicitly lists solar spectral irradiance. We propose that a distributed network of solar spectral irradiance monitoring cubesats is a promising concept to achieve these key goals. This pathfinder mission is low cost, utilizes a unique and proven student design program, and is perfectly timed to leverage an opportunity to piggyback aboard a high altitude balloon to demonstrate preliminary flight qualification.

Anticipated Benefits

Support NASA's strategic objectives to understand the Sun and its interactions with Earth and the solar system, including space weather. This will be achieved by developing/demonstrating instrumentation technology necessary to address the following science goals:

- Explore the physical processes in the space environment from the Sun to the Earth and throughout the solar system;
- Advance our understanding of the connections that link the Sun, the Earth, planetary space environments, and the outer reaches of our solar system;
- Develop the knowledge and capability to detect and predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth.

Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

University Corporation for Atmospheric Research (UCAR)

Responsible Program:

Heliophysics Technology and Instrument Development for Science

Project Management

Program Director:

Roshanak Hakimzadeh

Program Manager:

Roshanak Hakimzadeh

Principal Investigator:

Phil Oakley

Co-Investigators:

Paul Bryans
Ann Gumbiner
Scott W Mcintosh
James Nabity
Scott Sewell
Qian Wu

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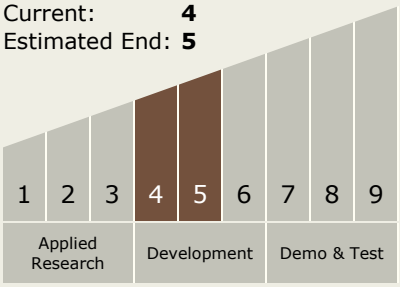
Organizations Performing Work	Role	Type	Location
University Corporation for Atmospheric Research(UCAR)	Lead Organization	Academia	Boulder, Colorado

Primary U.S. Work Locations
Colorado

Technology Maturity (TRL)

Start: **4**
Current: **4**
Estimated End: **5**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.1 Detectors and Focal Planes

Target Destination

The Sun